Coastal Engineering Technical Note

PROTECTIVE BEACHES - THEIR APPLICATIONS AND LIMITATIONS

PURPOSE: To describe the functional applications, limitations, and the general design concepts of protective beaches. This note is intended to provide a brief, general discussion of protective beaches for Corps personnel who do not have a background in the functional design of coastal structures, and to provide useful information for answering inquiries from the general public concerning the construction and use of protective beaches.

FUNCTIONAL APPLICATIONS: A protective beach (or beach fill) is a deposit of sand, artificially placed along a shoreline to provide a buffer zone between the sea and the backshore. It can be classified as a flexible structure since its shape is modified by wave action, tidal currents, littoral currents, or wind. The protective beach is composed of two functional types of beach fill: (1) beach restoration including landfills on beachfront property or that material placed on the beach to restore an eroded beach to the desired profile and (2) beach nourishment which is added as a sacrificial fill to be replaced when it has been eroded away (see the Figure). When properly designed and maintained, protective beaches can provide shore protection by dissipating wave energy and can also function as a recreational facility. A protective beach will change its shape to adapt to changing wave conditions, reflecting less wave energy and causing less erosion impact to adjacent beaches than other coastal structures.

A protective beach does not impede the flow of longshore currents carrying sand in-the way that a groin does; thus beach fill does not cause erosion to downdrift shorelines. As discussed in Coastal Engineering Technical Note III-10 (Groins), beach fills are sometimes used in conjunction with groins. An important advantage of protective beaches is that they remedy the basic cause of most erosion problems, a deficiency of natural sand supply, and they benefit rather than damage' the shore downdrift of them.

Protective beaches are adaptable to long reaches of shore and can be provided at a cost relatively low compared to costs of other shore protection structures. Unlike more rigid structures, protective beaches can be removed, if they prove to be detrimental, simply by discontinuing renourishment operations.

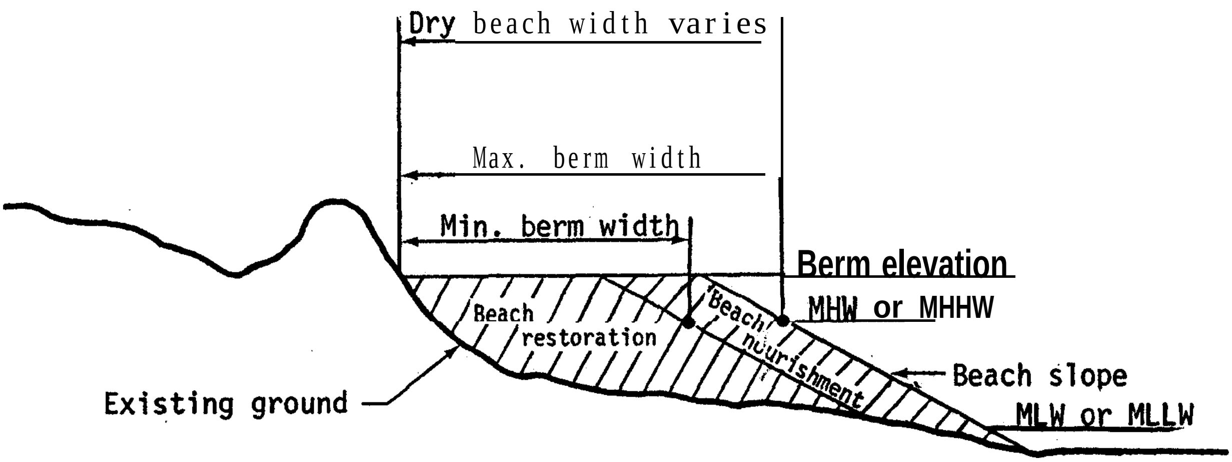

Figure. Typical Design Section

FUNCTIONAL LIMITATIONS: A protective beach functions by sacrificing itself to erosion that otherwise would damage the uplands. At some future time the beach will have to be replaced to maintain its protective value. To make an accurate comparison between a protective beach and other shore protection structures, it is necessary to predict the number of times a beach will have to be refilled during the functional life of a more durable structure. The life span of beach fill is a product of the erosion rate. The rate is determined primarily by the environmental conditions at the site and by the characteristics of the borrow sand used to build the beach. Historical shoreline changes can be used to estimate the future erosion rate. In some locations a large portion of the fill may disappear during a single severe storm; therefore, the accuracy of the lifespan predictions is dependent upon the accuracy of storm condition predictions. Short, steep waves which usually occur during winter storms, tend to erode the beach. Long swells, which originate from distance storms, tend to rebuild the beach. On most beaches, there is a constant erosion process of beach material by local storm waves followed by gradual rebuilding by swells. A series of violent local storms in a short time can result in severe erosion of the shore if there is not enough time between storms for swells to rebuild,the beach. Alternate erosion and accretion may be seasonal on some beaches; the winter storms erode the beach, and the summer swells rebuild it. There are stretches of shoreline (e.g. California) though, where littoral drift moving offshore and along the coast falls into submarine canyons and thus does not return to build back the beach.

STRUCTURAL ASPECTS: The following design parameters must be chosen to suit the beach's function and site.

1. Berm Elevation. The berm elevation is chosen to reduce the occurrence of overtopping by waves and storm tides. A dune may be added landward of the protective beach to provide additional protection against hurricane wave attack. Information on tide elevations and wave data are needed to evaluate the limitations on overtopping imposed by a proposed beach berm elevation.

2. Berm Width. Berm width is chosen to provide protection for a selected number of years before refill is necessary. The predicted erosion rates of fill material over the long term and when first placed must be estimated to determine the desired width. The long term rate can be calculated by applying the "Renourishment Factor," discussed in Chapter 5 of the *Shore Protection Manual* (SPM), to the erosion rate of the native beach sand. When new fill is first placed, much of the fine-grained material will be washed out immediately. To account for this early loss, extra fill must be added during placement. The additional berm width is calculated from the required volume, which in turn is calculated using the "Adjusted Fill Factor" described in Chapter 5 of the SPM. Both the "Renourishment Factor" and "Adjusted Fill Factor" are determined by comparing the grain size distributions of the native and potential fill sands. Site condition, such as a steep offshore beach slope, may limit the location of the seaward edge of the fill and consequently dictate use of a narrower berm than desired. On the other hand, the berm may be widened to meet greater recreational or other demands.

3. Beach Slope. The beach slope is usually chosen to match the slope of the existing beach, based on the assumption that the native sand has reached an equilibrium with existing forces. Fill which is coarser than native sand will tend to assume an angle steeper than the existing beach; hence, fill may be placed slightly steeper than the existing slope to reduce the volume of fill sand lost during initial adjustment to wave conditions. It is noted though, that as the beach slope angle increases, the potential for beach erosion is increased since steeper or more erosion-producing waves can reach the beach fill.

4. Beach Length. If fill is placed over a short stretch of shoreline, it may create a bump on the shoreline which focuses waves on the newly-placed fill, increasing its erosion. Unless this phenomena is used to distribute sand from a feeder beach, a protective beach must be transitioned into adjacent beaches to prevent abrupt changes in the wave regime or placed between hard points such as groins. In many cases, this requirement precludes use of a protective beach along a single private owner's shorefront property. Where the direction and volume of the longshore transport is accurately known, however, short stretches of fill or even discrete piles (stockpiles) may be placed at one end of an eroded beach, or at carefully chosen, intervals along. the beach; for the purpose of supplying sand to adjacent shores;. If the stockpiles are correctly spaced, the gaps between them will be completely filled as waves and littoral currents distribute the sand.

DESIGN CONSIDERATIONS:

1. In most cases, a restored beach must be renourished periodically in order to maintain its protection. The fill material should be the least erodible of the sands available and environmentally acceptable. The design beach slope should be chosen to limit losses from wave action during adjustment of the fill's shape, and the berm should be wide enough to keep an adequate amount of sand on the beach between renourishment periods. The fill should be spread over a sufficient length of beach and should be transitioned into adjacent beaches to prevent changing the wave regime which may increase erosion.

2. A-protective beach can provide sand for longshore transport to aid adjacent shorelines. Where this reduces erosion or promotes accretion of nearby

beaches, it is beneficial, but if the beach fill site is near a harbor there is danger of sand moving into navigation channels, causing detrimental shoaling.

3. A protective beach can be a recreation facility and improves access to the water. Where dunes are included as part of the project, access across the dunes may have to be restricted to prevent their being beaten down by foot and vehicular traffic.

MATERIALS SELECTION: The source of the fill material is the primary determinant of the method of placement, but environmental and economic factors must be considered. Selection of a borrow site will depend to a great extent on the ecological impacts of using the site, since many of the convenient wetland areas are environmentally sensitive. Sand, from underwater sources, is usually pumped into place as a slurry, but such hydraulic placement tends to wash away the finer materials in the borrow sand and cloud adjacent waters. Due to this clouding, hydraulic placement is environmentally unacceptable in some regions. In these areas pumped sand may need to be ponded and then distributed to the beach by scrapers. This process requires additional area for the pond and access to the beach for construction equipment. Sand, from upland sources, is usually placed using trucks and scrapers.

Fine sand generally erodes faster than coarse sand, but if coarse sand must be transported long distances to the beach site, the high costs may be prohibitive; therefore, the use of available, nearby sources of finer sand may be the only practical choice. If the offshore slope is steep, higher volumes of fill would be required for a beach of adequate dimensions and this may cause the structure to be uneconomical. Although providing protective beaches may be more economical initially than construction of other coastal structures, if frequent replenishment is required, the total volume involved can reverse the economic advantage.

REFERENCES:

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